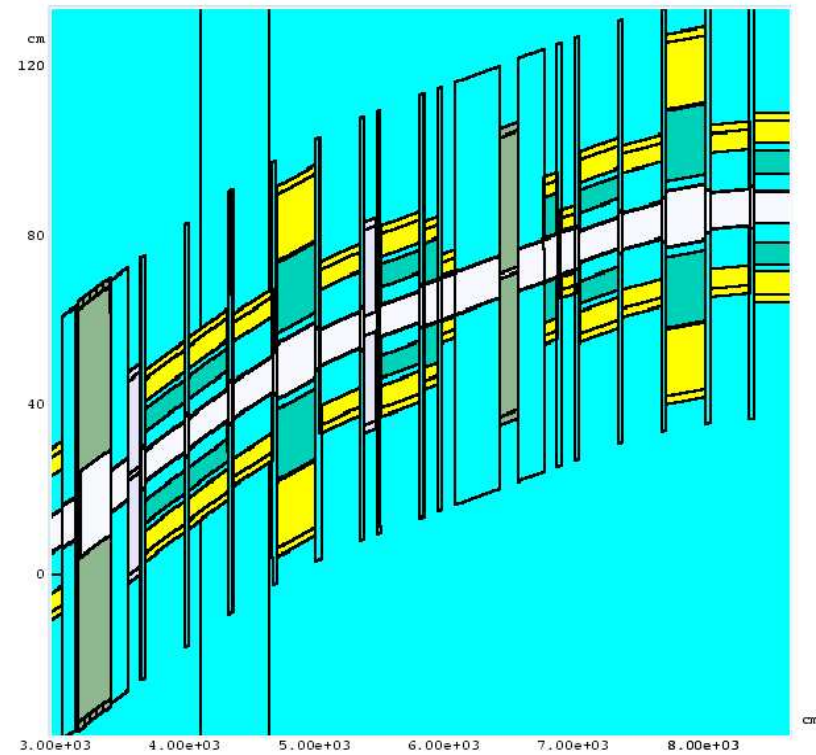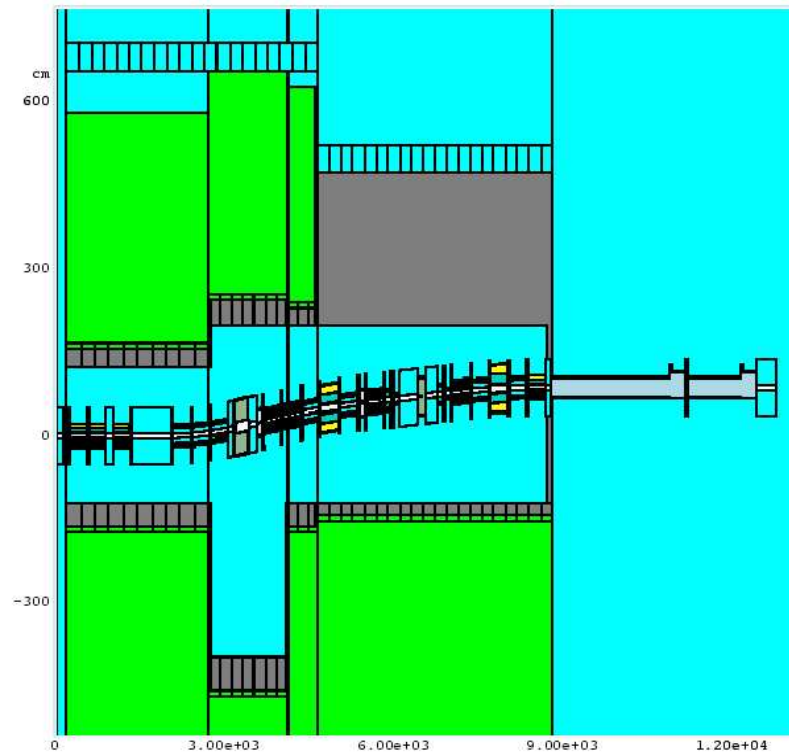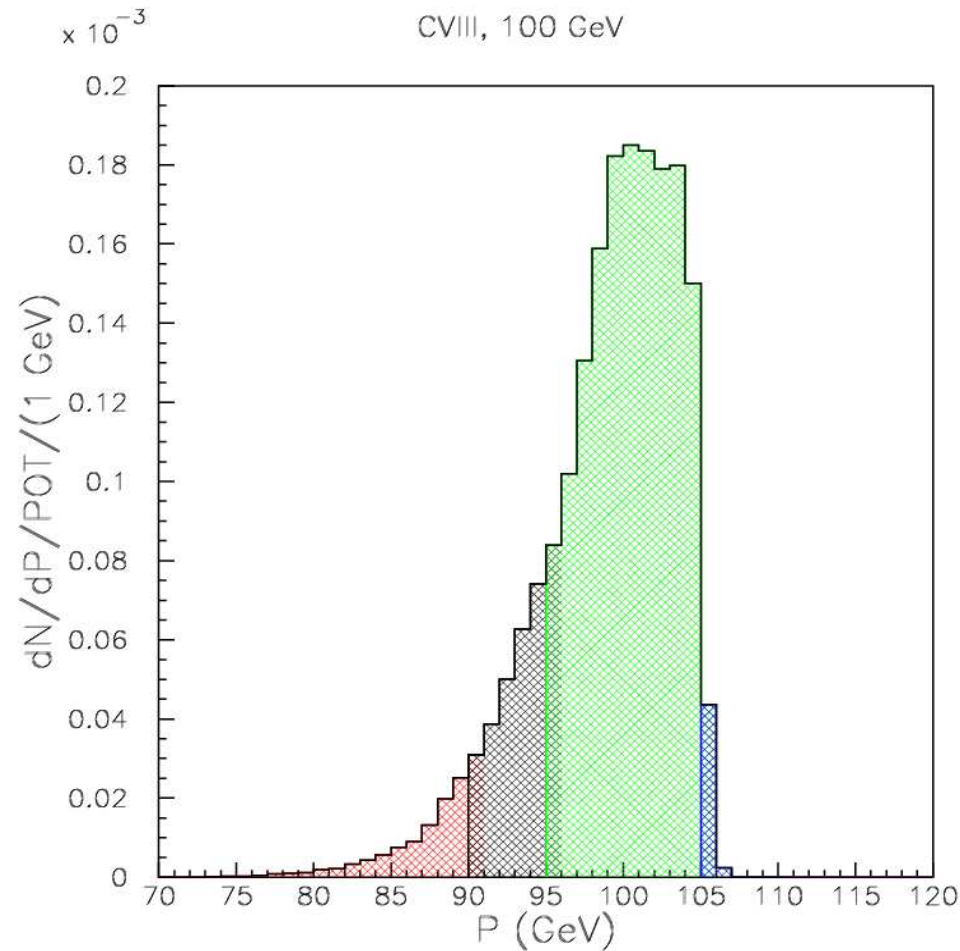# Beamline calculations with MARS14

Mikhail Kostin

Talk Outline

- Beam transport. Collimator and absorber apertures.

- Radiation issues

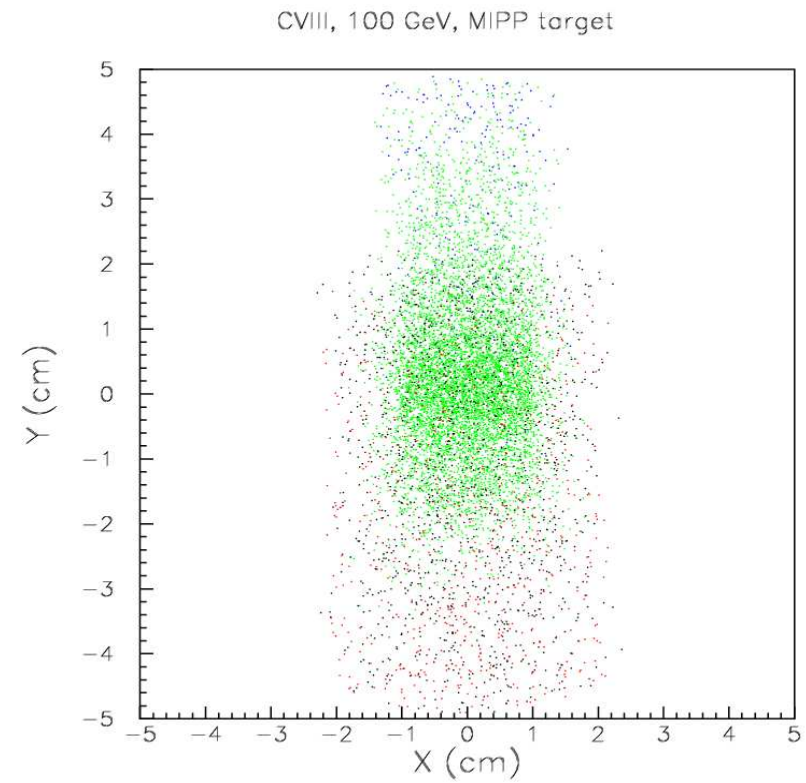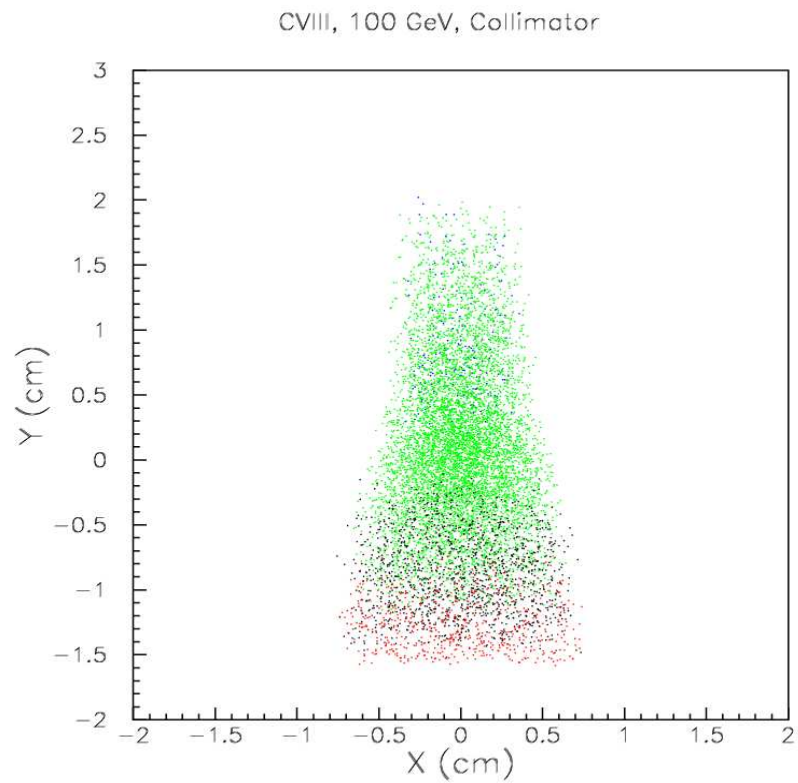- Target temperature regime

- Conclusions

Beamline. Elevation view.

Survived protons. Central momentum 100 GeV. 1.0e8 protons on primary target (POT)
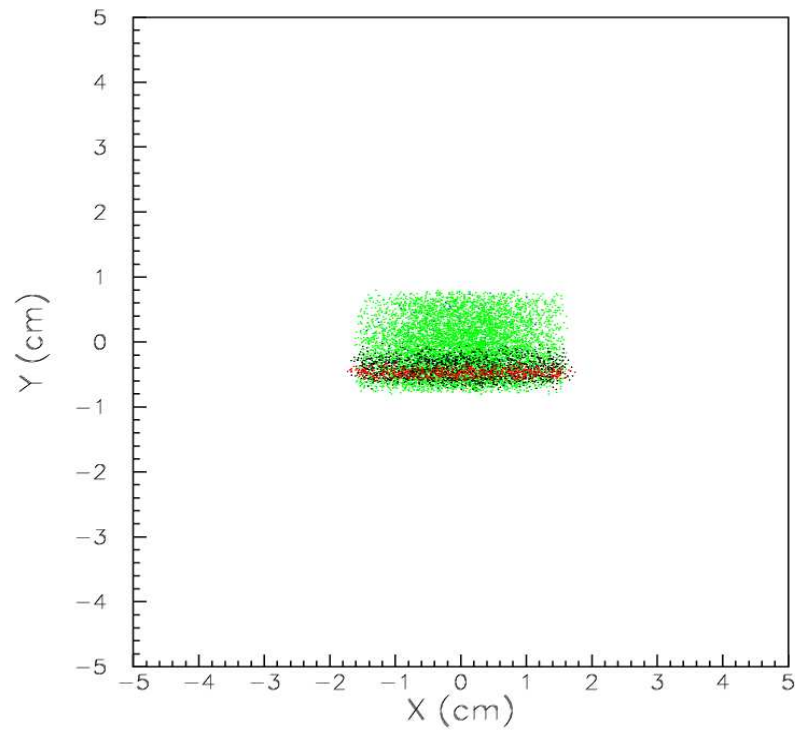
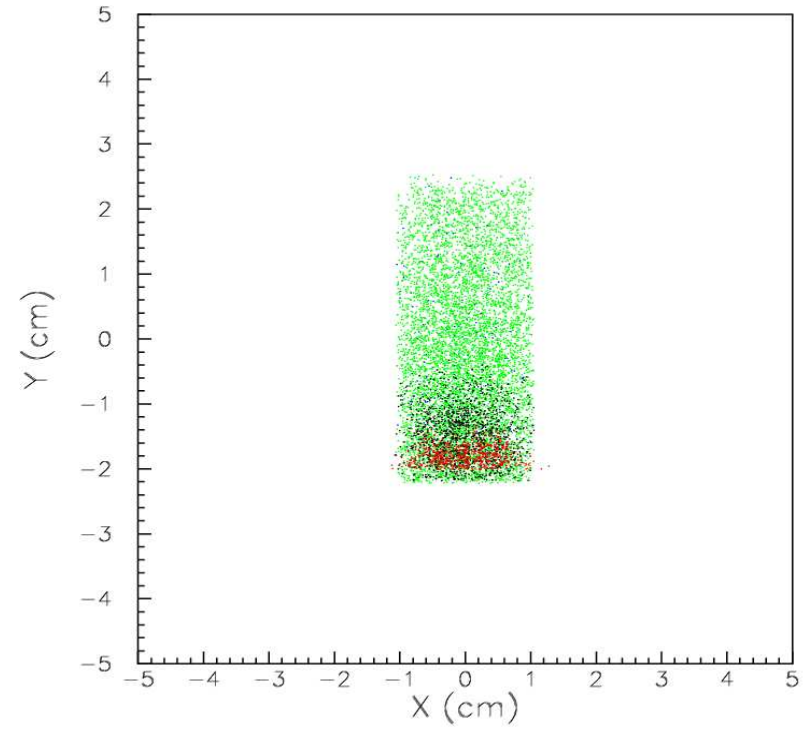# Survived protons at collimator and target.

Survived protons at scrapers.
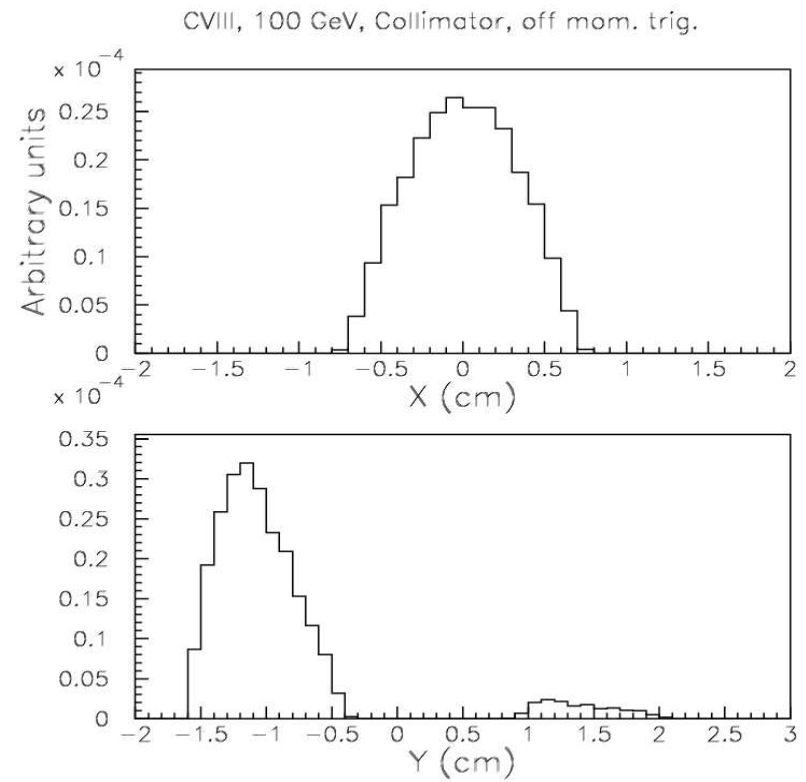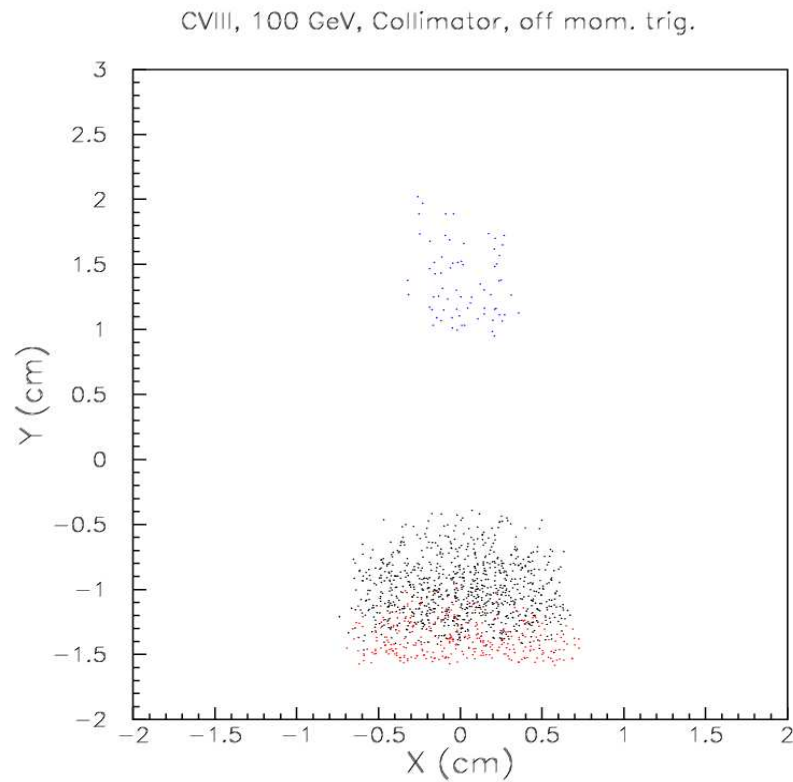
Scraper 1

Scraper 2

CVIII, 100 GeV, ET

CVIII, 100 GeV, 4Q
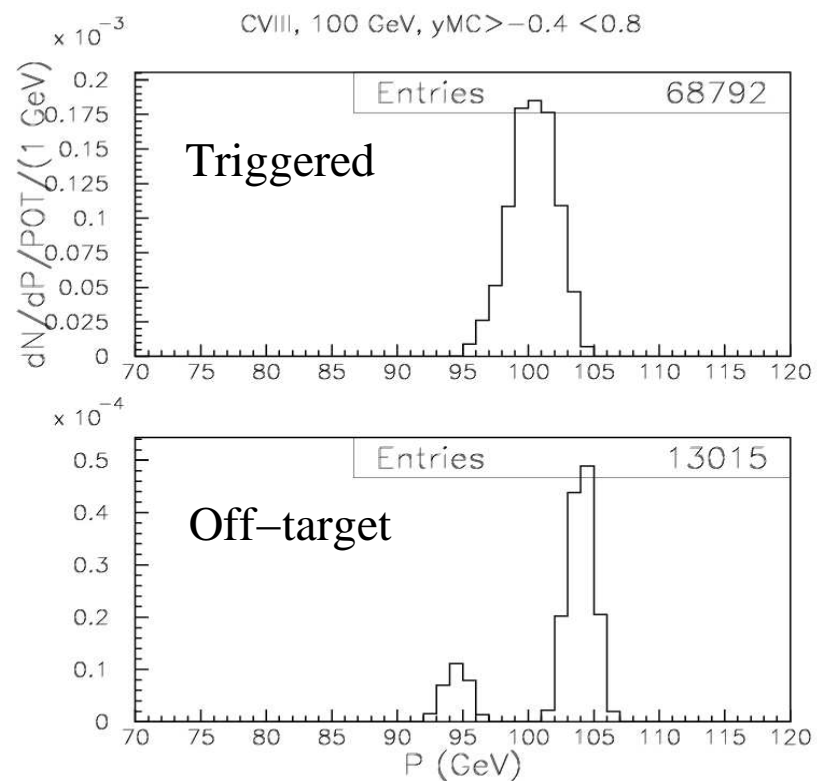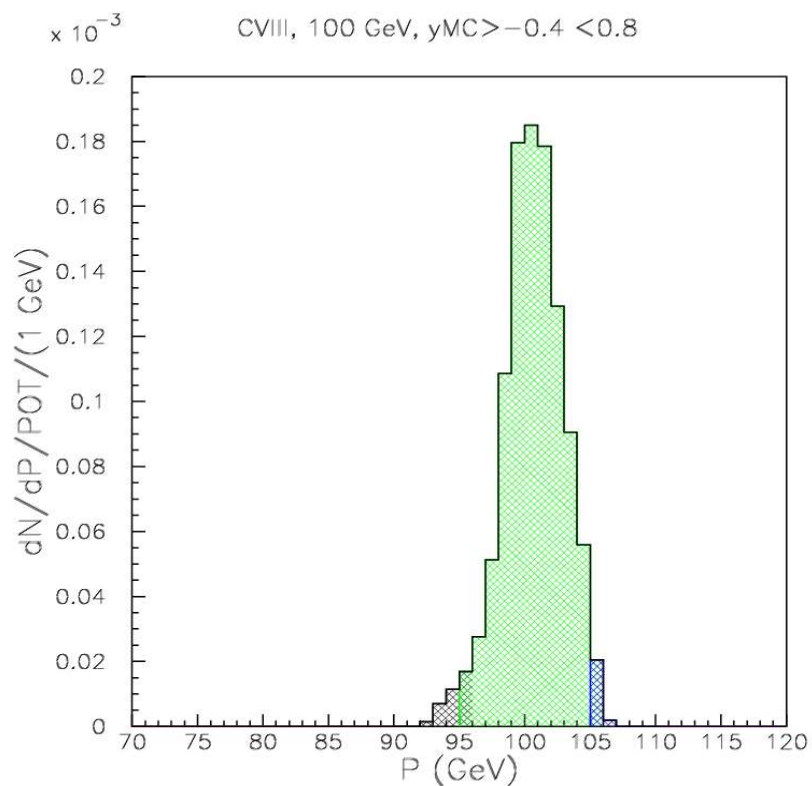
Off–momentum protons at collimator

(off 100+–5 GeV)

Collimator cut y > −0.4 cm, y < 0.8 cm

"Triggered protons" − in secondary target with radius of 2.5 cm
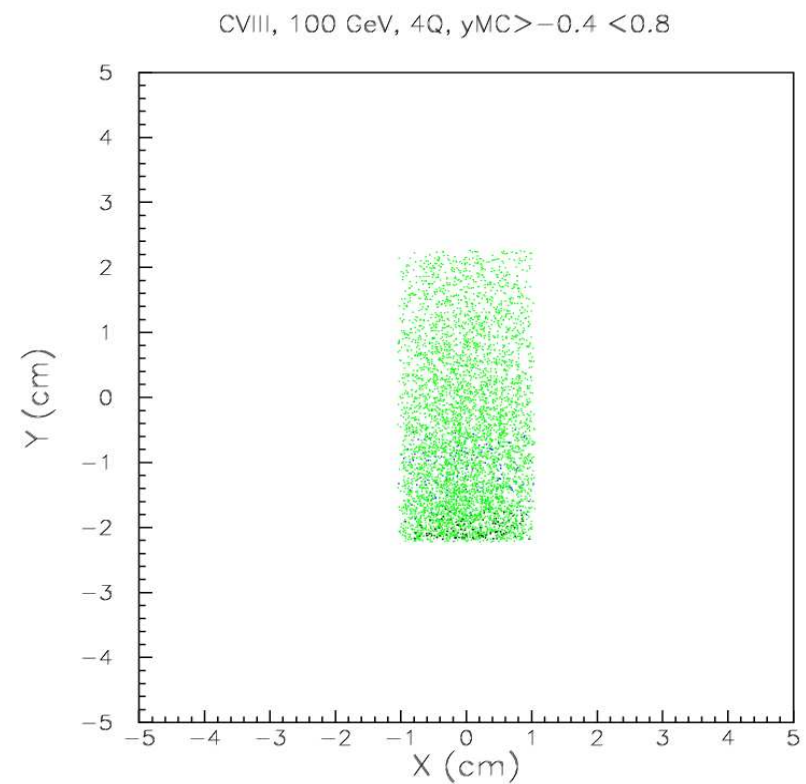
Collimator cut y > −0.4 cm , y < 0.8 cm

Scraper 1

CVIII, 100 GeV, ET, yMC>−0.4 <0.8

Scraper 2

CVIII, 100 GeV, 4Q, yMC>−0.4 <0.8
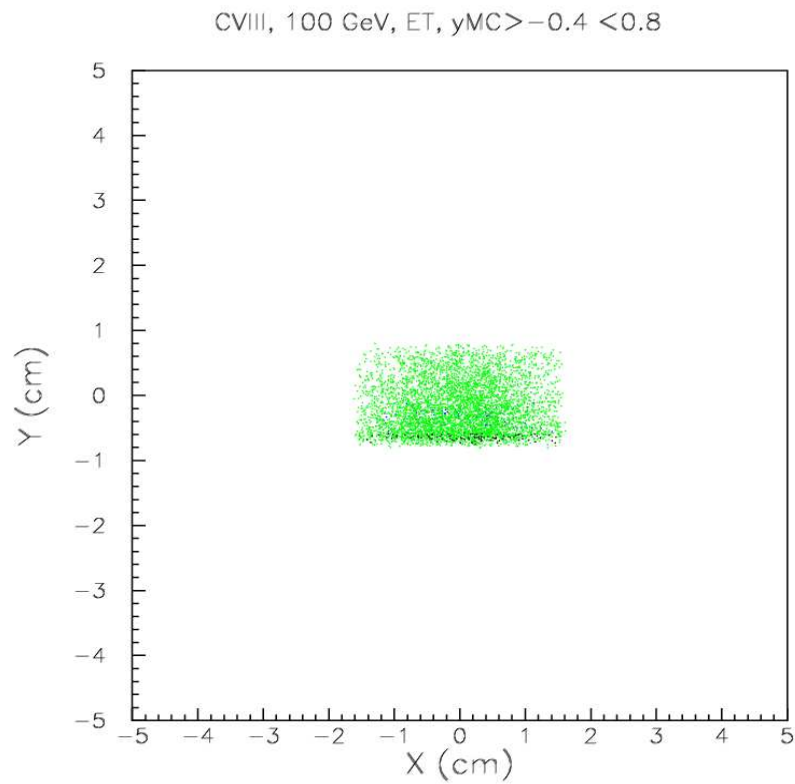
Collimator cut $y > -0.4$ cm, $y < 0.8$ cm
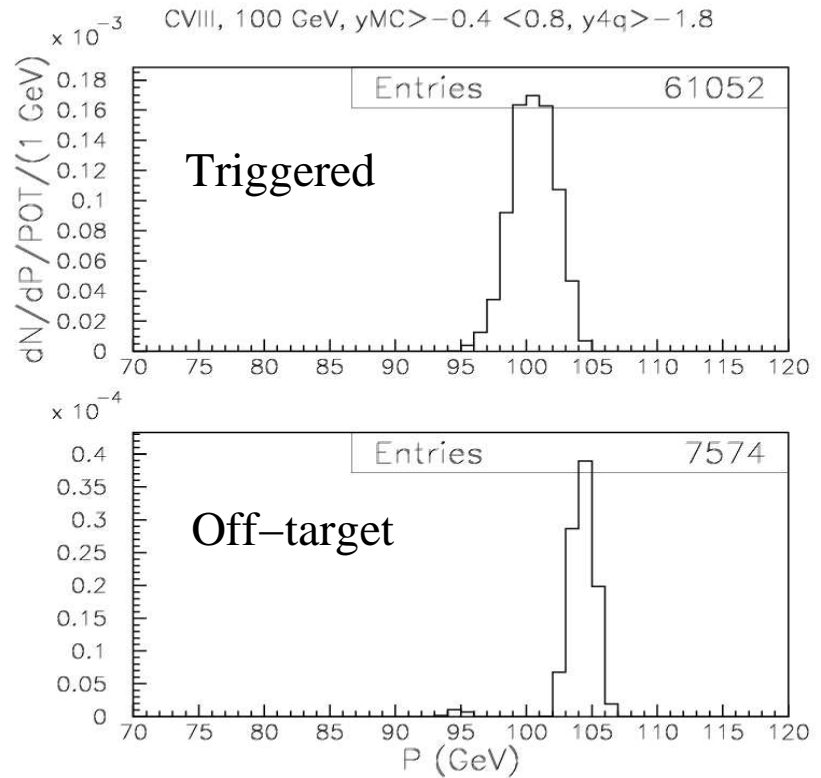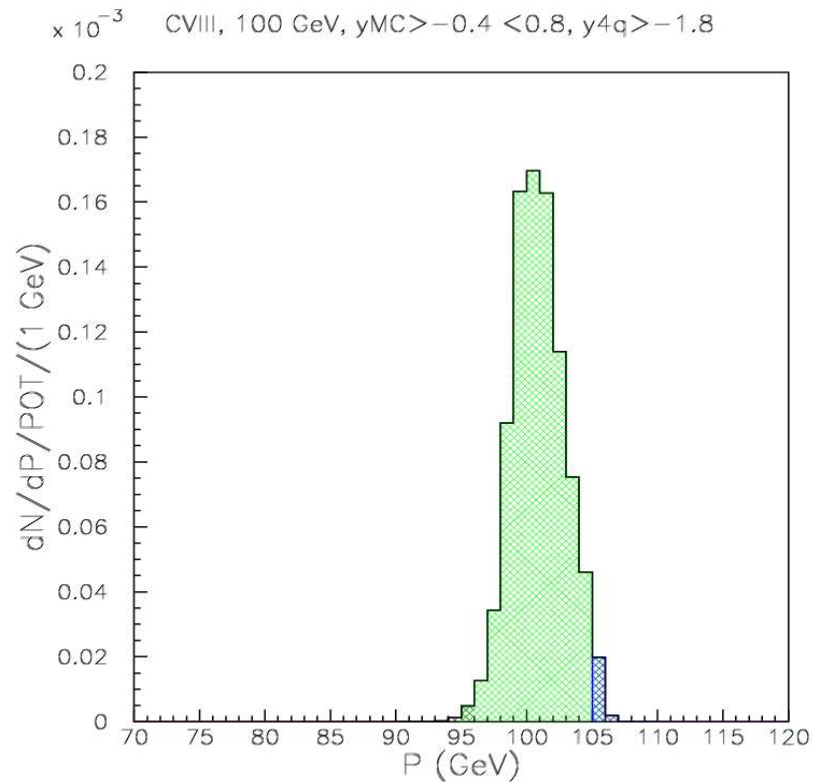
Scraper 2 cut $y > -1.8$ cm

Collimator cut $y > -0.4$ cm, $y < 0.8$ cm
Scraper 2 cut $\quad y > -1.8$ cm

Y vs. X at secondary target

Angle at secondary target

CVIII, 100 GeV, MIPP target, yMC>−0.4 <0.8, y4q>−1.8

Y (cm)

X (cm)

CVIII, 100 GeV, MIPP target, yMC>−0.4 <0.8, y4q>−1.8

acdczt

$\times 10^{-2}$
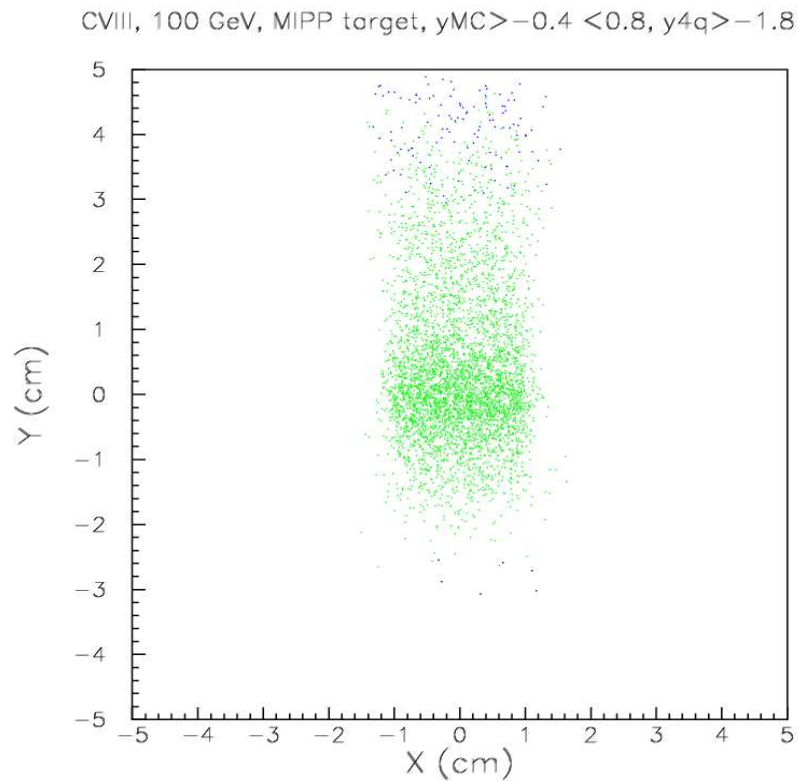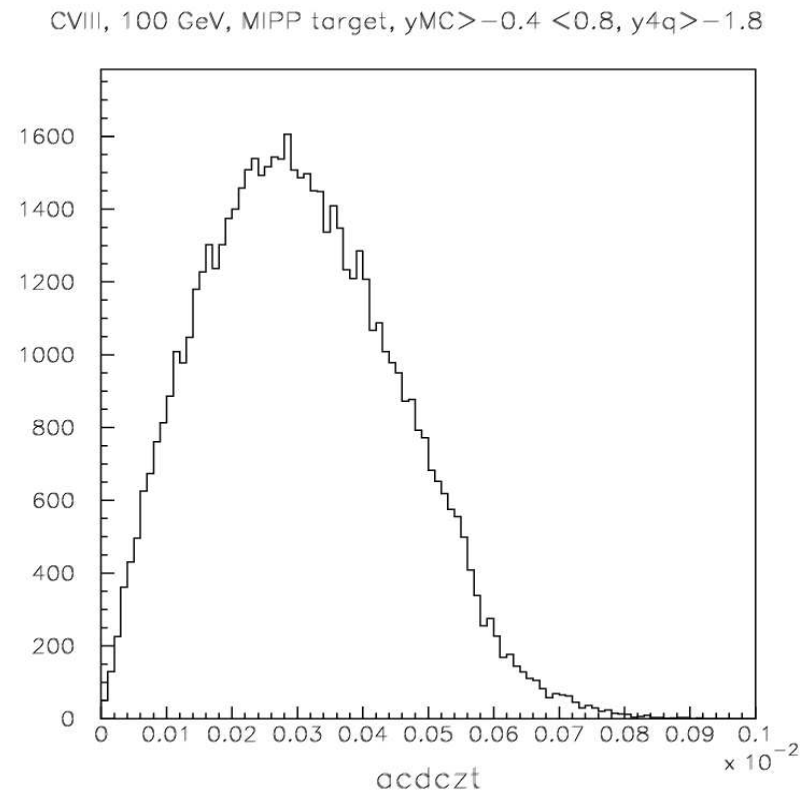
Off–momentum (+– 3%)

X and Y projections at collimator

Various collimator cuts for +−3% beam
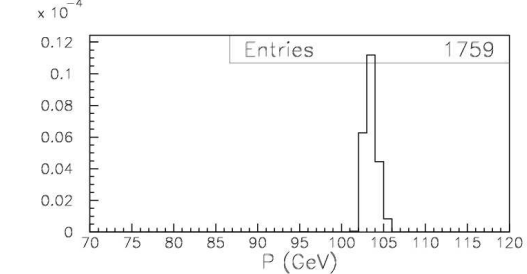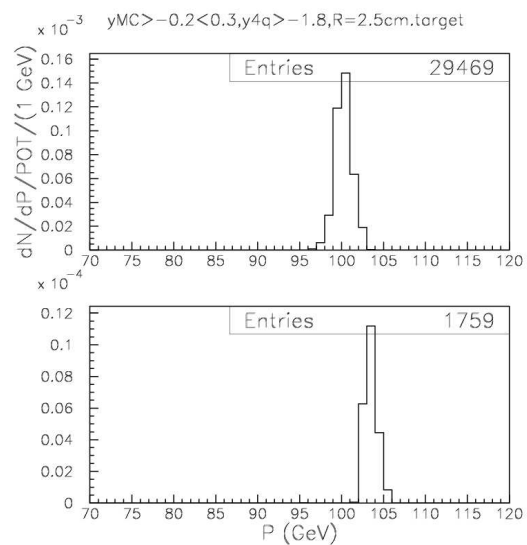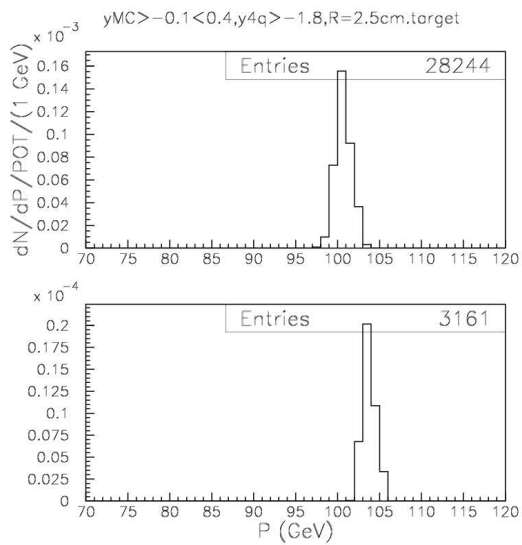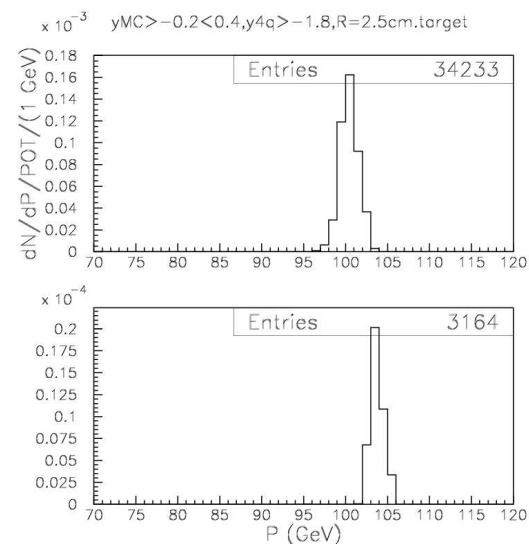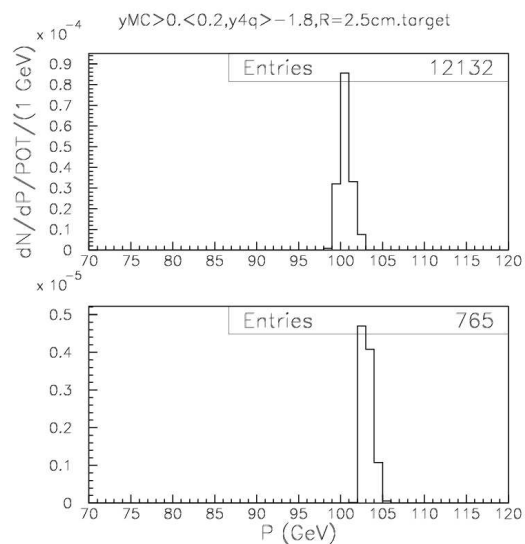
Various collimator cuts for +–3% beam
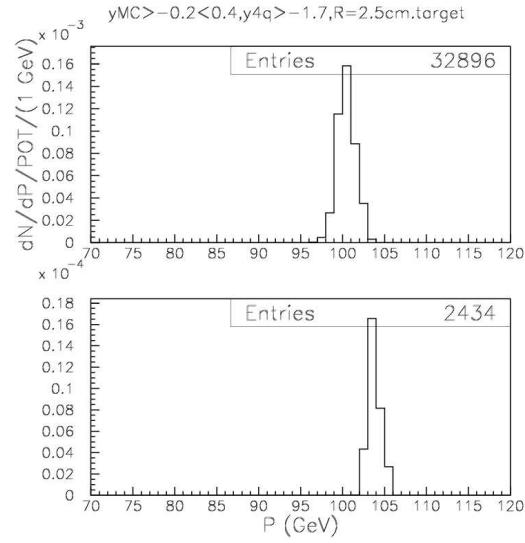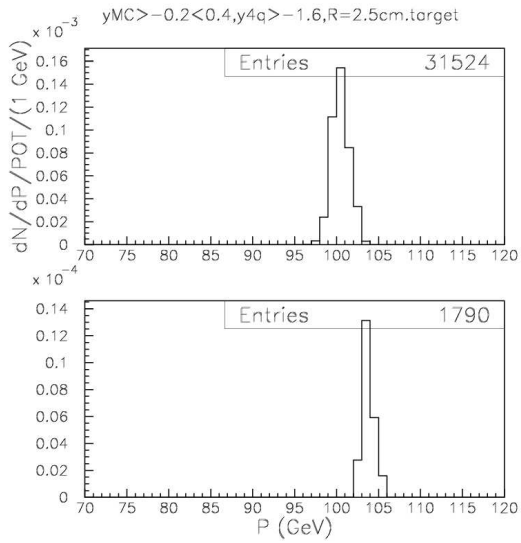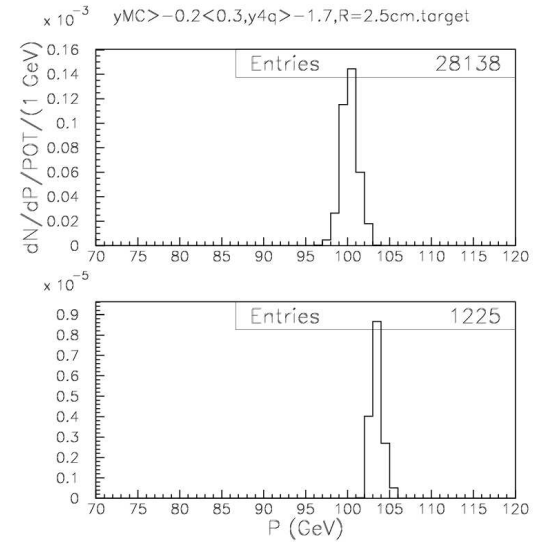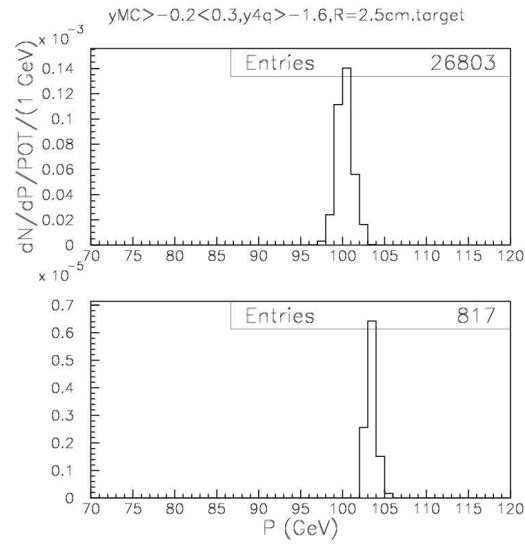
Radiation issues

- Sump water activation due to ^{3}H, ^{22}Na decays
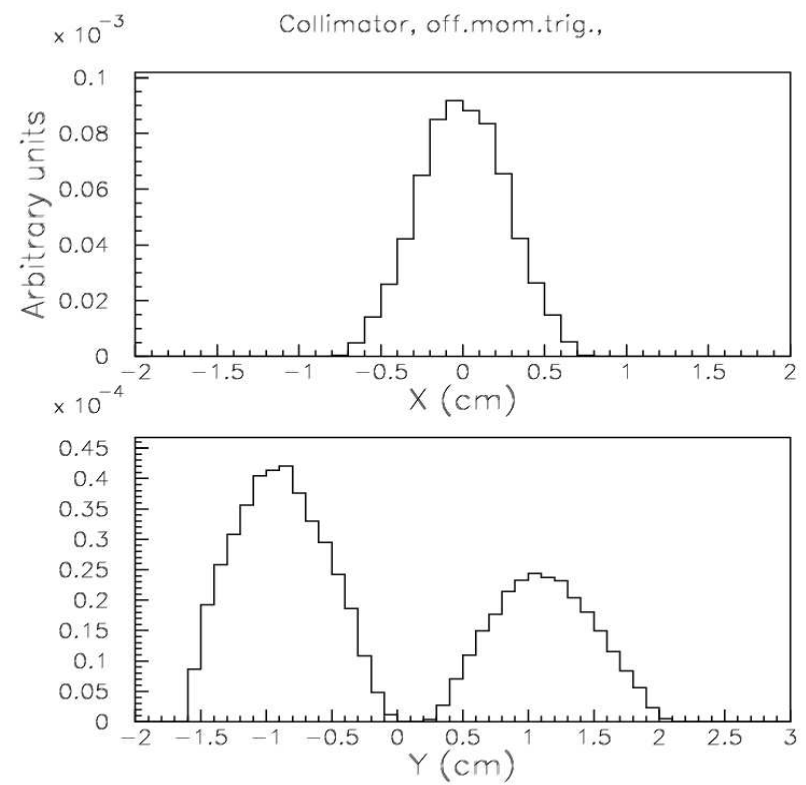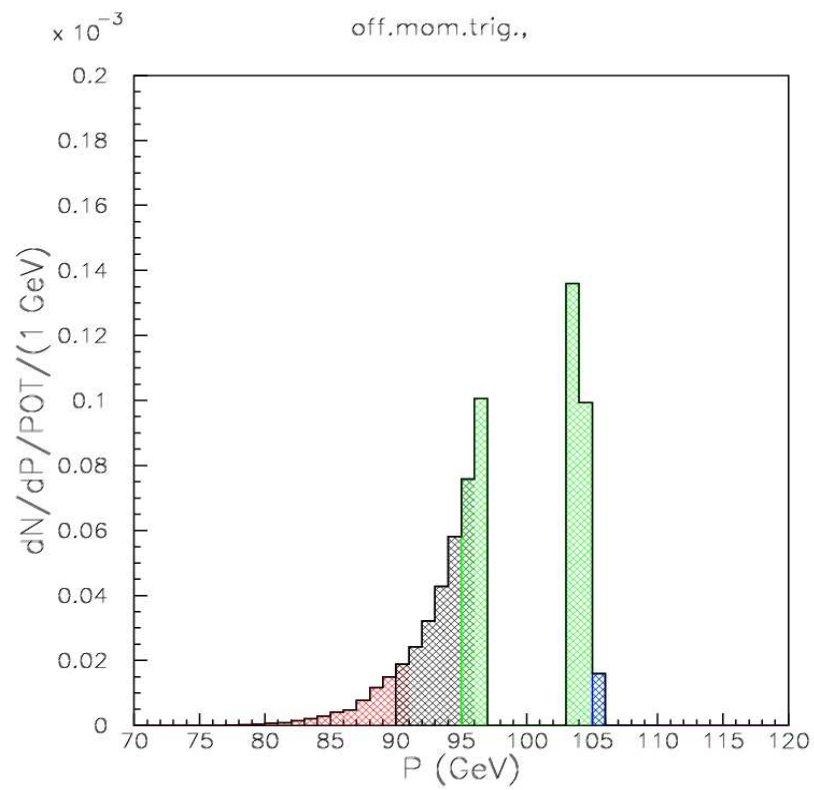 Limit 2,000 star / (cc sec) (?)

- Residual activation (on–hands maintenance dose)
  Guideline: $P_{Gamma} <$ 100 mrem / hr after 30 days of
  irradiation and 1 day of cooling (or 100 days / 4 hr)

- Radiation damage to magnet coils (epoxy, cable insulation)
  $<$ 400 Mrad in life time

- Prompt dose
  - Non–controlled Area: $<$ 0.05 mrem / hr
  - Controlled Area: 0.05––5 mrem / hr
  - Radiation Area: 5 ––100 mrem / hr
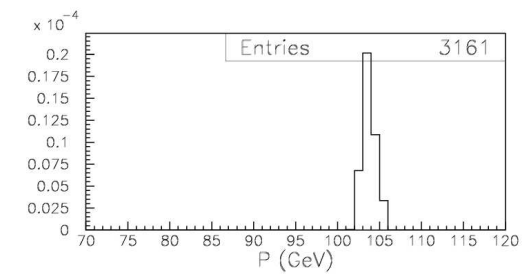 - High Radiation Area: 100––500,000 mrem / hr
  - Very High Radiation Area: $>$ 500,000 mrem / hr

- Air activation (Never addressed)

Beam enclosure and beyond.

Sump water

Maximum

Target shielding

8"

-5cm

0   20cm   250cm
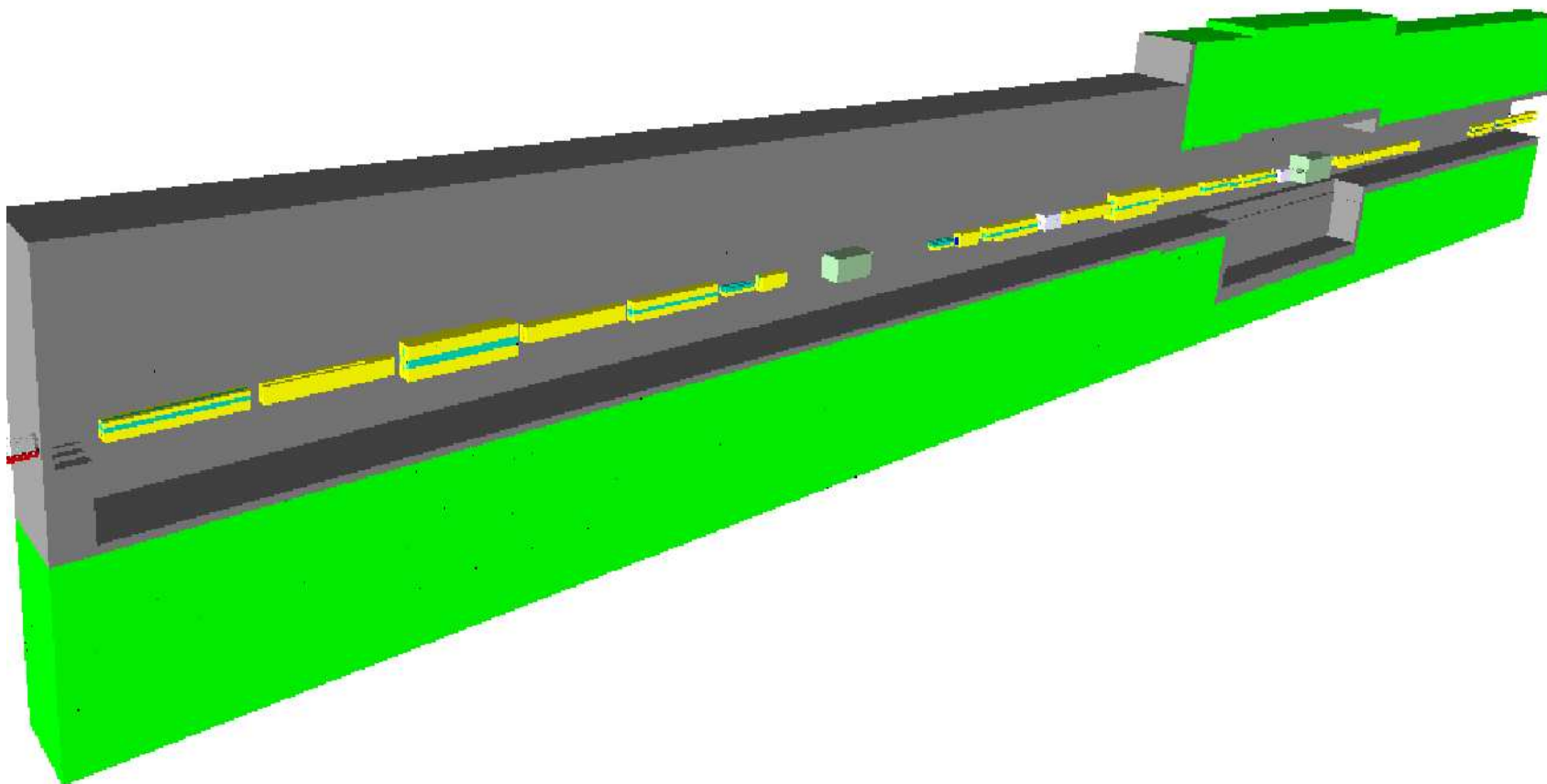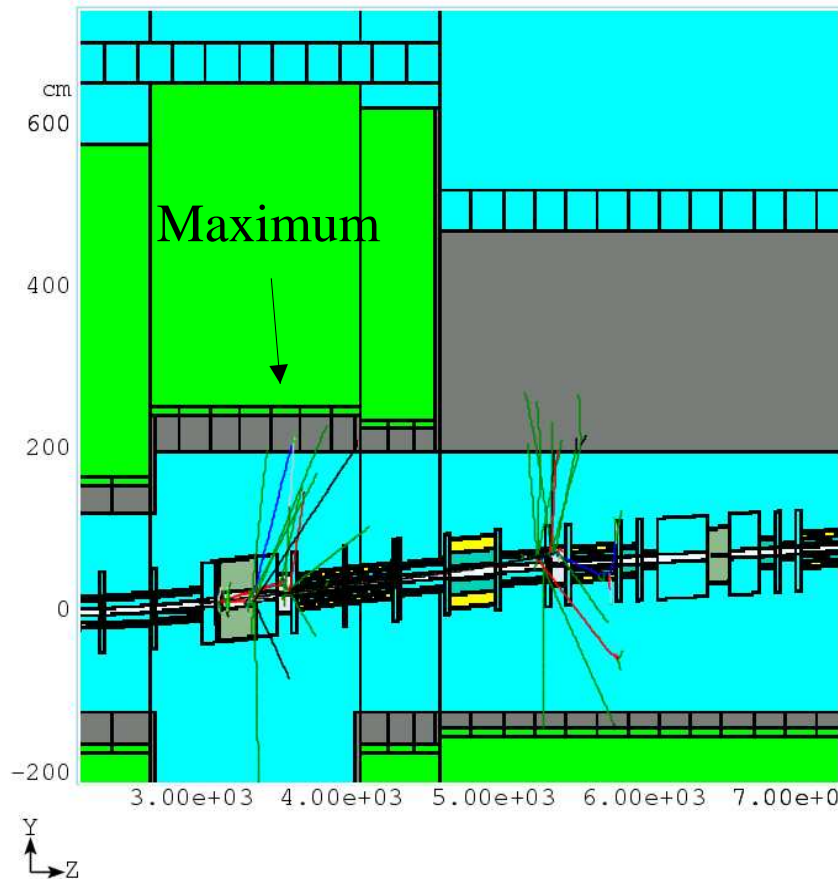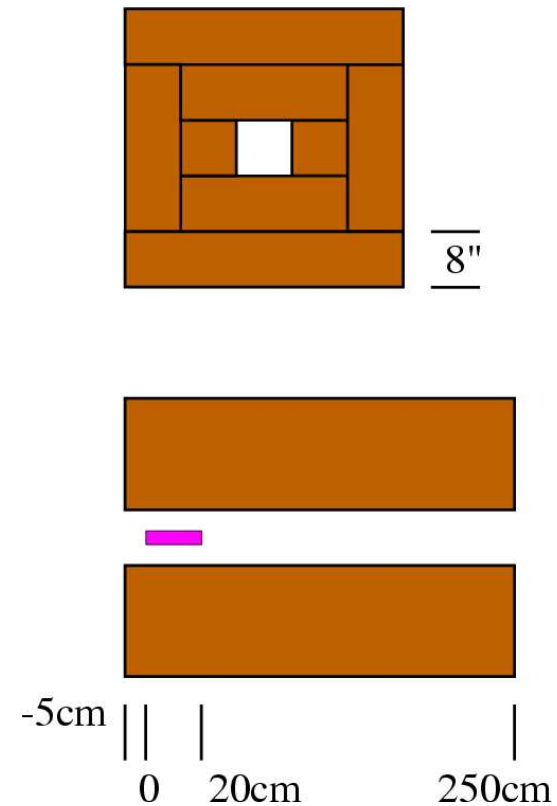
ST max=(2.76+–0.11)e–7 star / (cc proton)
ST max*1.0e16 proton/year = 0.276e10 star/year
ST limit=5.96e10 star/year

Residual Activation

Residual Dose after 30 days of irradiation and 1 day of cooling

I=2.54e10 proton/sec

Margin factor 2–3 for Dose !

Target is too close to the front surface of shielding. Dose on target 1 Mrem/hr !

First peak can be brought down by placing the scraper 1 into the target shielding.

1 day / 1 day dose is only 3–4 times smaller, i.e. 1 week / 1 day dose is close

Residual Dose, −90 GeV

Plot: P$_\gamma$ (mrem / hr) vs Beam Element. Labeled points: Scraper 1 (front) ~2000, Scraper 2 (top) ~1100, 3Q, EPB, Target sh. (rear), 3Q.
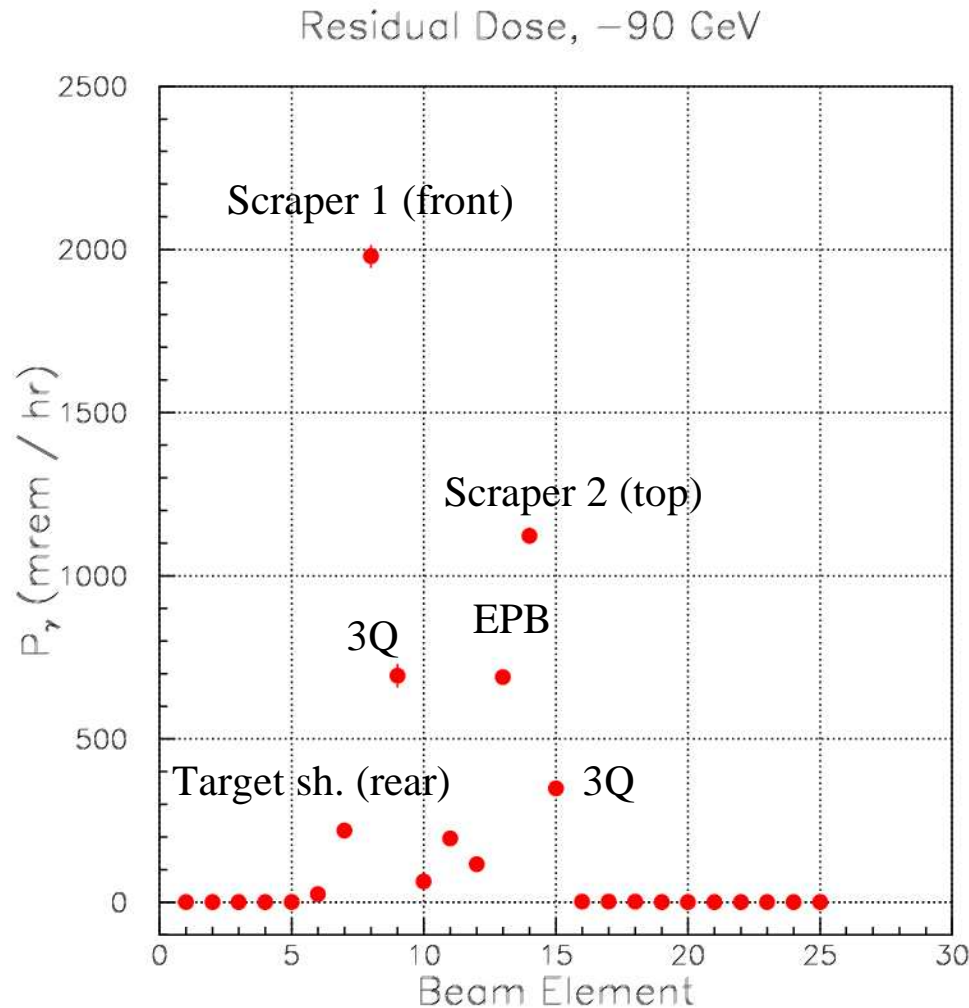
Coil irradiation

Absorbed dose in coils (averaged over a year)
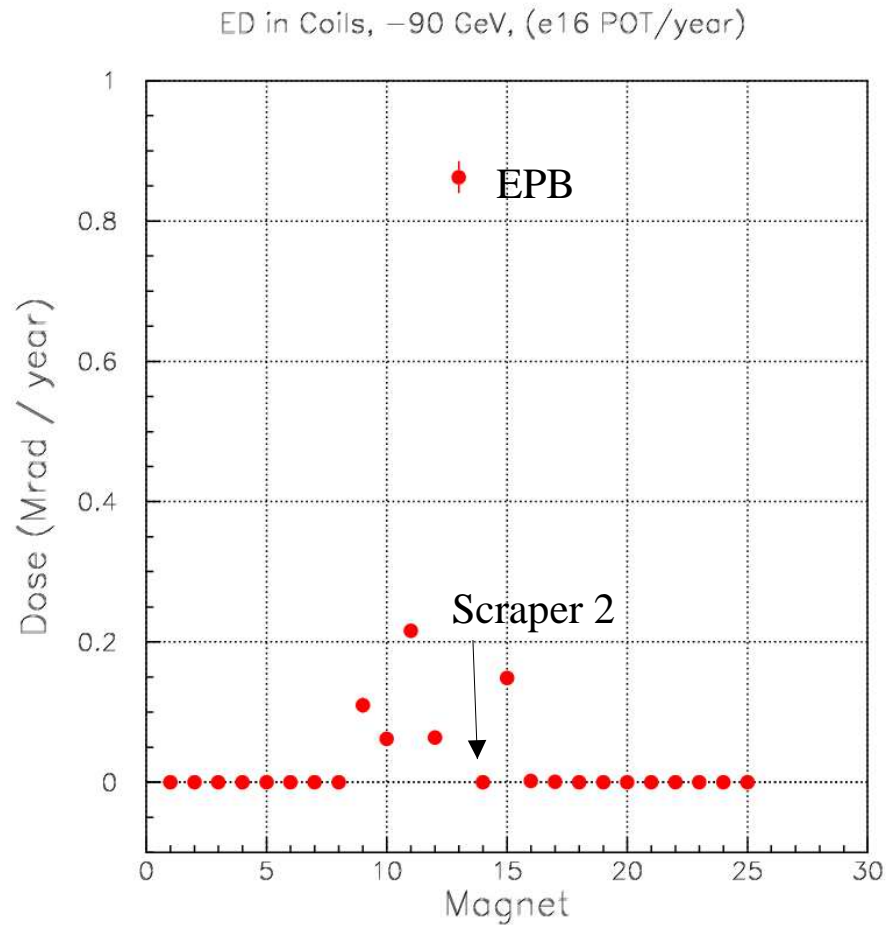
No point–like losses with bulk scraper 2 !?

ED in Coils, −90 GeV, (e16 POT/year)

EPB

Scraper 2

Dose (Mrad / year)

Magnet

−90 GeV
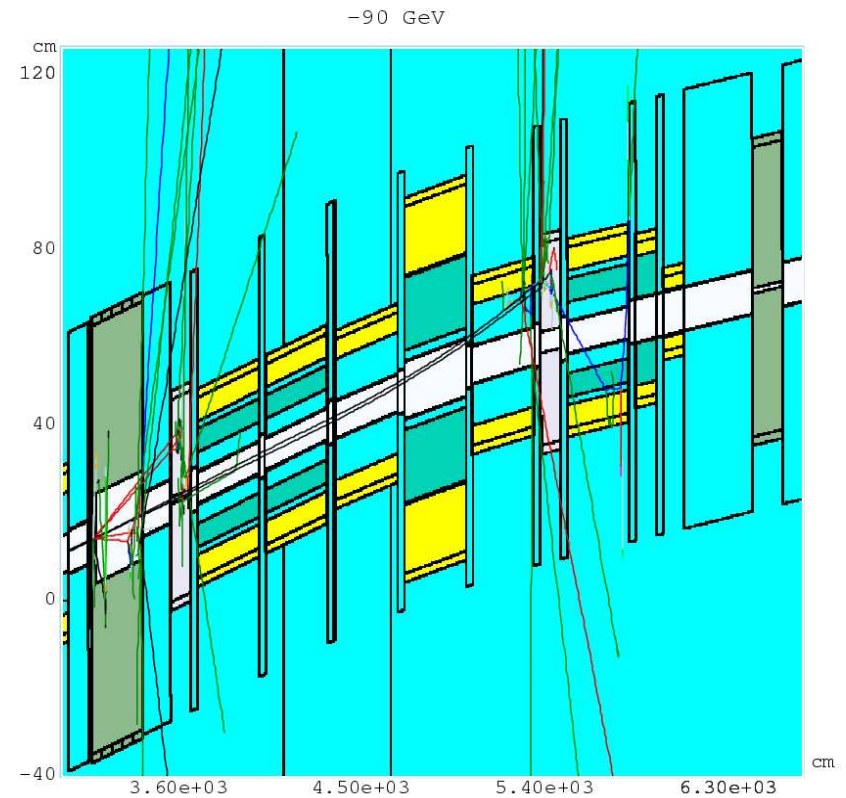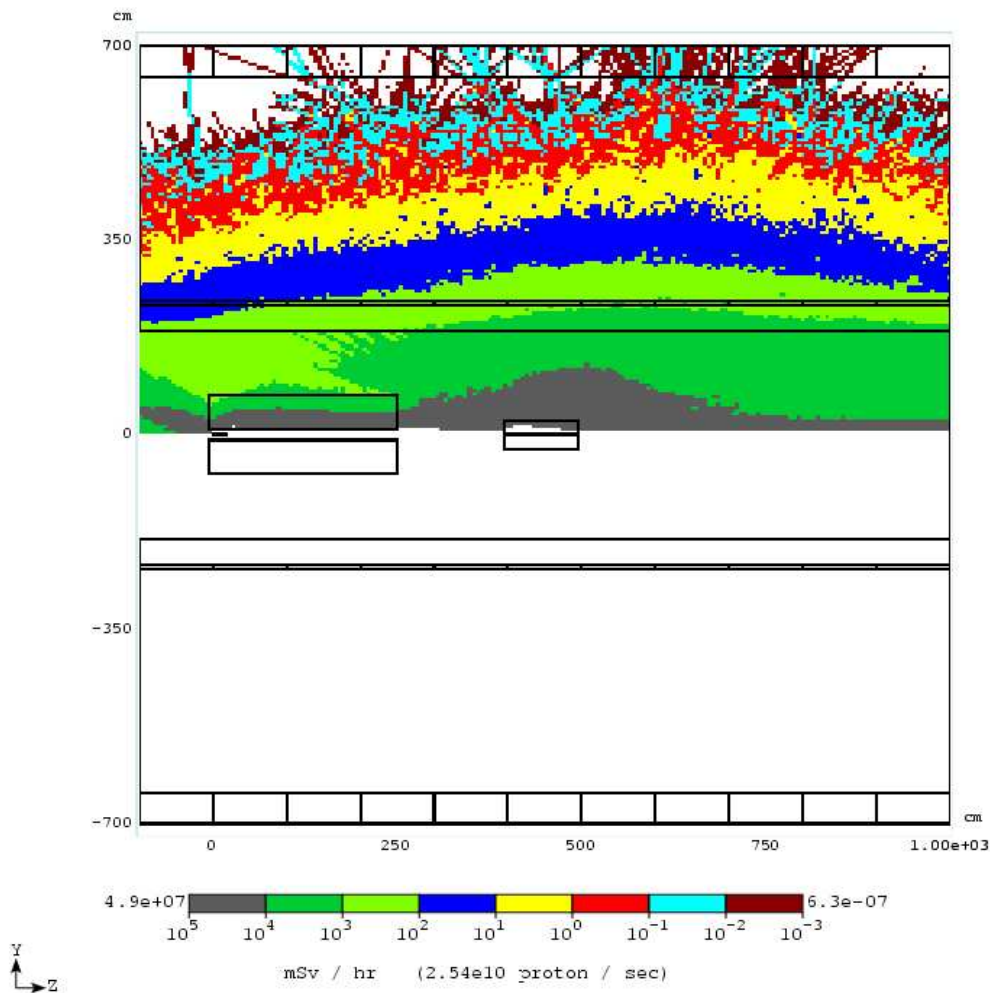
Prompt Dose

Estimated from a simplified model prompt dose after 15' of soil = 4 mrem / hr (+− 50%)

Main contribution from scraper 1. Dose will be reduced to be below the radiation area limit (5 mrem/hr) by putting the scrapper inside of the target shielding and adding one extra steel plate to the top of shielding.

Expected prompt dose in the Meson Building 20 mrem / hr with 2m of concrete and 0.8m of steel around hot spot (scraper 2).

Target temperature

Energy Deposition simulated with MARS14. ED map fed into ANSYS. Assume instant deposition from 7.62e10 protons per spill every 3 second (double spill).

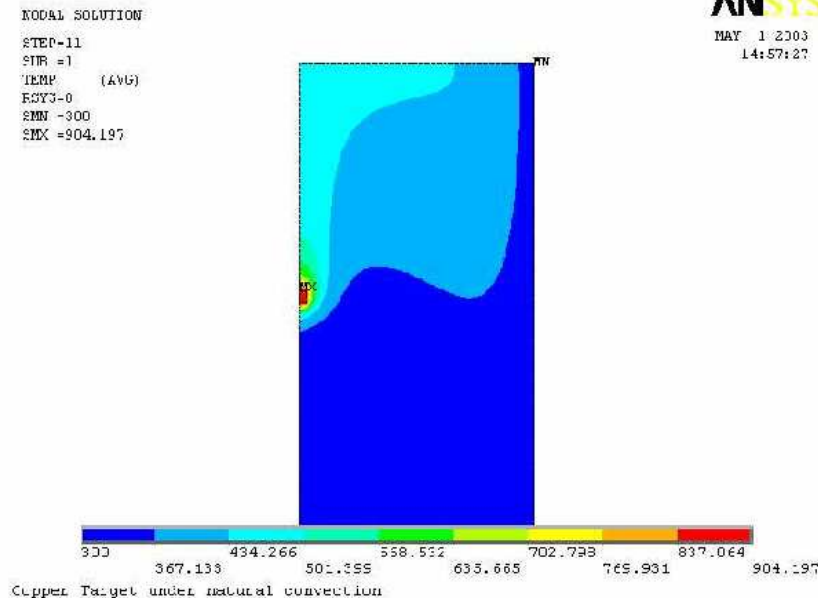Geometry: copper target + 10 cm air in each direction. Boundary temp. of the system fixed to 300 K. Air convection heat transfer only.

Temp. increase after one pulse < 5 C
Tmax(CU) = 631 C
Cu melting point 1083 C

NODAL SOLUTION
STEP=11
SUB =1
TEMP (AVG)
RSYS=0
SMN =300
SMX =904.197

ANSYS
MAY 1 2003
14:57:27

300   434.266   568.532   702.798   837.064
   367.133   501.399   635.665   769.931   904.197

Copper Target under natural convection

Conclusions

* Beam optics is ready. Apertures of collimator and scraper are known

* Secondary target radius is 2.5 cm (? decided ?)

* OK for sump water, absorbed dose in coils.

* Most likely OK for Prompt Dose. Radiation Area in Meson Building.

* High residual activation due to beam dump onto magnets.

* Do we need more realistic simulation for target temp. build–up ?